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EVALUATION OF AN ELECTRIC, HORIZONTAL,
DUAL-CONVEYOR BROILER

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Army Natick Laboratories
Natick, Massachusetts

December 1972

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TECHNICAL REPORT

73-27-GP

EVALUATION OF
AN ELECTRIC, HORIZONTAL, DUAL-CONVEYOR BROILER

by

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Project Reference:
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FOREWORD

The Navy Subsistence Office at the DOD Food Service Facility and Equipment Planning Board Meeting of 3, 4, and 5 February 1970 requested the U. S. Army Natick Laboratories to test and evaluate an electric, horizontal conveyor broiler for use in military food service operations.

Acknowledgment is made to the Food Service Equipment and Evaluation Team, Food Systems Equipment Division, General Equipment & Packaging Laboratory for the performance testing of the broiler.

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ABSTRACT

A commercial electric, horizontal conveyor-type broiler was evaluated to determine its acceptability for use in military food service operations. Evaluation consisted of broiling hamburgers, cheeseburgers, frankfurters, and buns, stressing food production, and an examination of the sanitary and safety aspects of the equipment. The broiler is not considered acceptable for garrison food service feeding, where hamburger patties are served without buns, because of the generally unacceptable appearance of the patties. The broiler is more practical in specialty houses and snack bars, wherever the quantity of short order meals requires a large amount of hamburgers on buns.

The equipment is safe to use. The major drawback in the use of this equipment is the difficulty in cleaning.

EVALUATION OF AN ELECTRIC, HORIZONTAL, DUAL-CONVEYOR BROILER

1. Introduction

An electric, horizontal, dual-conveyor broiler was evaluated to determine its suitability for garrison food service operations and whether an automatically timed conveyor method of broiling provides food superior to food normally cooked on non-automatic broilers and griddles. Four major equipment aspects were evaluated: (1) design (2) food production capability (3) safety and (4) sanitation.

2. Description of Equipment

The broiler used in this evaluation, shown in Figure 1, is a countertop model*. It measures approximately 137.16 centimeters (54 inches) long by 71.02 centimeters (28 inches) wide by 55.88 centimeters (22 inches) high and is mounted on four legs. Electrical components are designed for 208 volts, 60-Hertz, 1-phase, a.c. and the broiler is rated for 9.6 Kilowatts.

The broiler has one 30.48-centimeter (12-inch) wide conveyor and one 15.24-centimeter (6-inch) wide conveyor. Heat for broiling is provided by 12 snap-in resistance elements located in a heating chamber above and below the conveyor belts. Controls are provided for selection of the top element and either one or two bottom elements. Cooking is electrically timed and the speed of each conveyor is variable.

The control panel is located at the loading end of the conveyor belts and contains an upper element heat switch, two lower element heat switches, a speed control for the 15.24-centimeter (6-inch) conveyor, and a speed control for the 30.48-centimeter (12-inch) conveyor.

A trough and receptacle are provided below the belts to collect grease. A 15.24-centimeter (6-inch) and a 30.48-centimeter (12-inch) pan are also provided to receive the cooked product at the conveyor belt discharge point.

3. Food Preparation Procedures and Results

a. Conveyor Times - The conveyors were operated at various speed settings without energizing heating elements to determine time from loading to discharge end, interval between adjacent hamburgers, interval between adjacent buns, and time in the heating chamber. Intervals between first and second hamburgers and first and second buns were taken with outside edges of hamburgers and buns touching each other.

*Conveyor Heat Products Corp., Model 2206; 2030 Clements Avenue, Pennsauken, New Jersey 08110.

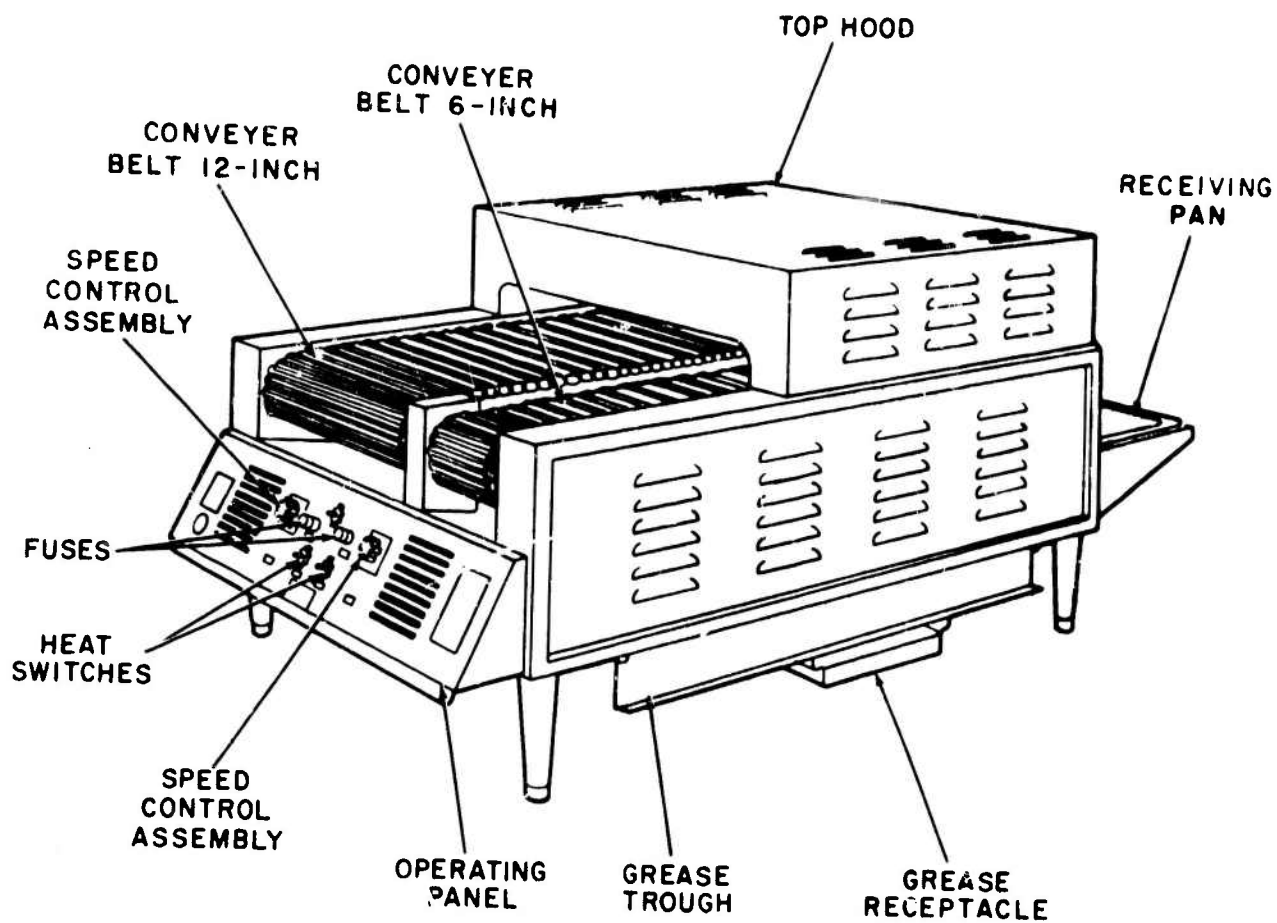


Figure 1. General View of Broiler.

Table I. Conveyor Times for 30.48-Centimeter (12-inch) Wide Belt

Belt Speed Setting	Travel Time from* Entrance to Exit	Interval between First & Second Hamburger	Time in Heat Chamber
	In Min/Sec	In Sec	In Min/Sec
100	1 20	9.0	48.0
90	1 23	9.0	50.0
80	1 39	11.0	59.5
70	2 29	17.0	1 27.5
60	3 48	25.0	2 16.0
50	5 37	35.9	3 15.0
45	6 43	45.8	- --
40	8 26	56.8	4 38.0
30	13 16	91.0	11 32.5
20	22 20	155.4	13 47.5
10	35 12	246.0	27 7.2
*Length of time for a hamburger placed on front of conveyor to pass through the unit and fall off discharge end.			

Table II. Conveyor Times for 15.24-Centimeter (6-inch) Wide Belt

Belt Speed Setting	Travel Time from* Entrance to Exit		Interval between First & Second Hamburger	Time in Heat Chamber	
	In Min/Sec		In Sec	In Min/Sec	
100		47.0	8.4		29.0
90		46.0	8.2		28.0
80	1	0.8	11.2		37.0
70	1	30.4	16.4		55.6
60	2	13.8	25.0	1	20.6
50	3	11.4	34.8	2	56.0
40	4	44.7	51.4	2	51.7
30	6	49.8	73.8	4	5.2
20	10	56.3	111.2	6	41.3
10	17	37.8	---	11	34.2
*Length of time for a two-section hamburger bun placed on front of conveyor to pass through the unit and fall off discharge end.					

b. Actual Cooking Times. Hamburgers, buns, cheeseburgers, frankfurters, toast, and toasted cheese sandwiches were cooked. Cooking times for hamburgers, buns, and frankfurters are as shown in Tables III, IV, and V, respectively.

(1) Hamburgers. Hamburgers measured approximately 10.63 centimeters (4-3/16 inches) in diameter before cooking and approximately 9.21 centimeters (3-5/8 inches) in diameter after cooking. Fat content did not exceed 22 per cent by weight. Hamburgers were cooked on the 30.48-centimeter (12-inch) wide conveyor and placed two across the conveyor width. Best results were obtained with a belt speed setting of 45 with top and both bottom elements used. The quantity could be increased by approximately one-third by placing three staggered hamburgers across the conveyor width.

(2) Frankfurters. Frankfurters were placed on every third grid on the 30.48-centimeter (12-inch) wide conveyor and cooked using the top and two bottom elements. Actual cooking times are shown in Table IV. Frankfurters were also cooked on the 15.24-centimeter (6-inch) wide conveyor with a speed setting of 40 as recommended by the manufacturer and results were good.

(3) Buns. Buns were cooked on the 15.24-centimeter (6-inch) wide conveyor using the top and two bottom elements.

Table IIIa. Actual Cooking Times, Hamburgers (Top and One Bottom Element).

Belt Speed Setting	Quantity of Hamburgers	Initial Temperature		Initial Weight	Final Temperature		Final Weight	Total Time	Percent Yield	Condition
		°C	°F		°C	°F		Min / Sec		
50	14	6.0	42.8	39	80.0	176.0	32	9 40.2	82%	Medium Rare
40	14	5.9	42.6	40	84.6	180.2	28	15 44.0	70%	Done

Table IIIb. Actual Cooking Times, Hamburgers (Top and Two Bottom Elements).

		Initial Temperature		Initial Weight	Final Temperature		Final Weight	Total Time	Percent Yield	Condition
		°C	°F		°C	°F		Min / Sec		
100	14	5.7	42.5	40	44.5	112.0	39	2 17.1	97.5%	Raw
90	14	5.8	42.6	40	41.8	107.3	39	2 12.2	97.5%	Raw
80	14	5.7	42.5	40	45.6	114.2	38 $\frac{1}{2}$	2 41.0	96.2%	Raw
70	14	5.8	42.6	41	64.2	147.5	38	4 6.7	92.7%	Raw
60	14	5.8	42.6	40 $\frac{1}{2}$	75.6	168.0	35	6 8.0	88.8%	Raw Center
50	14	5.7	42.5	40	82.4	180.4	30	9 35.1	75.0%	Medium Center
40	14	5.7	42.5	40	96.0	204.8	27 $\frac{1}{2}$	15 37.3	68.7%	Well Done
45	14	5.8	42.6	40 $\frac{1}{2}$	88.7	191.8	28 $\frac{1}{2}$	12 46.0	70.3%	Done (Best)
45	80	7.2	42.6	226	88.7	191.8	166	41 56.5	73.4%	Done (E.st)

Table IV. Actual Cooking Times, Frankfurters (Top and Bottom Elements).

Belt Speed Setting	Quantity of Frankfurters	Initial Temperature		Final Temperature		Total Time	Condition
		°C	°F	°C	°F	Min / Sec	
100	6	11.2	52.0	24.0	75.2	1 25.5	Not browned
90	6	14.4	57.9	26.2	79.0	1 25.5	Not browned
80	6	11.2	52.0	28.2	82.7	1 42.5	Not browned
70	6	12.7	54.8	36.0	96.7	2 33.0	Not browned
60	6	12.0	53.7	68.8	156.0	3 56.0	Slightly browned
50	6	11.2	52.0	80.8	177.4	6 23.5	Too brown
55	6	14.7	58.3	80.0	176.0	4 55.2	Good (Best time for Frankfurters)

Table V. Actual Cooking Times, Buns (Top and Two Bottom Elements).

Belt Speed Setting	Quantity of Buns	Initial Temperature		Final Temperature		Total Time	Condition
		°C	°F	°C	°F		
100	2	21.1	70.0	38.8	101.9	52.2	Not browned
90	2	21.1	70.0	40.2	104.3	53.1	Not browned
80	2	21.1	70.0	47.6	117.6	1 10.0	Not browned
70	2	21.1	70.0	63.2	145.8	1 39.4	Started browning edges
60	2	21.1	70.0	76.8	170.3	2 33.0	Slightly browned
50	2	21.1	70.0	86.2	187.0	3 49.5	Too browned
55	2	21.1	70.0	82.0	179.7	3 12.0	Good (Best time for buns)

(4) Cheeseburgers. Raw hamburger patties were cooked on the 30.48-centimeter (12-inch) wide conveyor at a belt speed setting of 45. A slice of cheese was then placed on the cooked patty and it was run through the broiler on the 15.24-centimeter (6-inch) wide belt at a belt speed setting of 100. The cheeseburger was then immediately put in a bun. The top and both bottom elements were used. The results were fair but the cheese was not completely melted.

(5) Cheese sandwiches. Cheese sandwiches were cooked according to the manufacturer's recommendations but an acceptable product was not obtained. The top and both bottom elements were used. Sandwiches toasted satisfactorily on the top side only and when the sandwiches were run through the broiler a second time, the top side burned.

(6) Toast. Bread was toasted but only the top side was toasted satisfactorily as with cheese sandwiches. The top and both bottom elements were used.

4. Observations Relating to Design, Sanitation, and Safety Aspects

a. Findings

(1) The broiler was completely assembled when received. There were no sharp edges, no exposed wiring, and inside wiring was of adequate gauge. Two legs were bent when the unit was uncrated.

(2) No indicating light was provided to show when electric power is available at the broiler.

(3) Difficulty and amount of time involved in cleaning is the major problem with the broiler. It takes 5 minutes to disassemble removable parts and 8 minutes to reassemble; 15 minutes to wash and clean the machine; and 40 minutes to wash removable parts, excluding the conveyor belts. The belts were very difficult to clean. The grease and residue from hamburgers were burned on the belt. The belts were left to soak in a cleaning solution overnight. This barely affected the surface. Belts were then boiled in a strong cleaning solution for about 60 minutes, with two periodic scrubbing. Even after boiling, the belts had to be scoured with a scouring pad to remove remainder of burned food which took about 10 minutes. Total cleaning time, including boiling of belts exceeded 2-1/2 hours. Additional time is also required to allow the machine to cool prior to disassembling.

(4) The amount of smoke and fumes generated during broiling is considered excessive. The manufacturer does market an attaching hood for removing smoke and fumes, but the cost is considered relatively high.

(5) The top of the heating chamber becomes very hot during cooking.

(6) Grease splattering out of discharge end of machine causes grease burns and makes handling of cooked product difficult.

(7) Grease from the conveyor belts at the loading end drips onto the control panel causing a safety and sanitation problem.

(8) There were very few to no blood bubbles on the cooked product when cooked in accordance with paragraph 2 b (1) and Table III b, however, when 3 patties were placed across the belt width and the belt speed was increased to obtain the manufacturer's advertised production rate, the blood bubbles increased greatly and appearance was not generally acceptable.

5. Conclusions

a. Suitability for use

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(1) The broiler is not considered suitable for garrison food service operations where hamburger patties are not used with buns. but in snack bars and specialty houses, where the quantity of short order meals requires large amounts of hamburgers with buns, the broiler would give a more consistent product than a griddle.

(2) The difficult cleaning involved with the machine makes it unacceptable for use in a food service facility that has to meet military sanitation requirements.

(4) Hamburgers and frankfurters can be cooked satisfactorily with fair appearance and taste, but buns, toast, and toasted cheese sandwiches are not toasted evenly.

(5) The broiler should be located beneath an exhaust hood, or the manufacturer's attaching hood should be used.

b. Needed design improvements

(1) The addition of a signal light to indicate power is "on" at the machine would increase the ease of operation.

(2) The addition of a shield or the relocation of the controls away from the loading end of the conveyor belt would eliminate drippage on the controls.

(3) The addition of a hood would remove smoke and fumes and provide a more workable environment for cooks.

(4) An increase in material thickness of leg bolting components would provide greater strength and stability.